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SEASONAL VARIATIONS IN THE PLANKTON

of

FLORENCE LAKE

by

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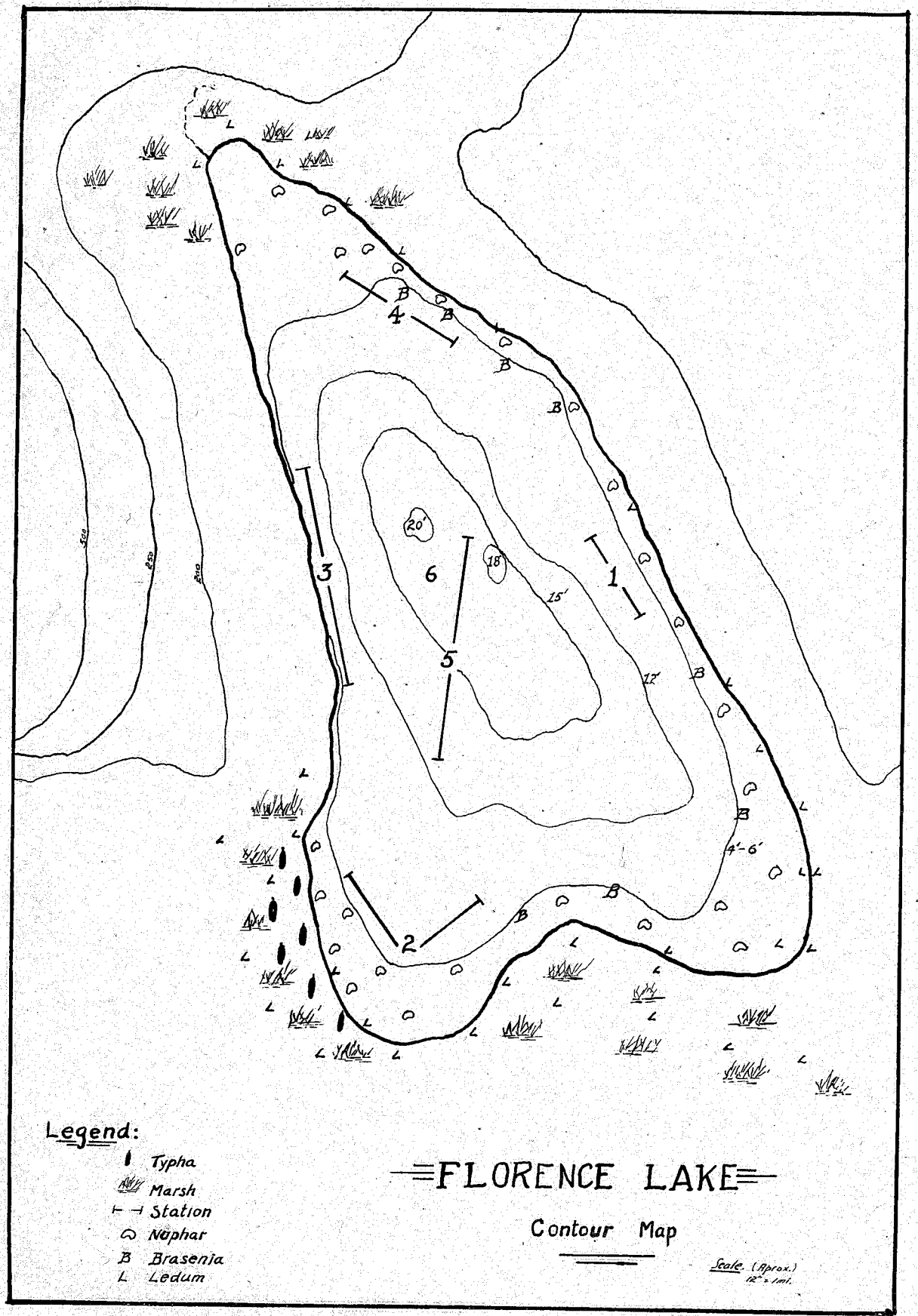
INTRODUCTION

Any work on fish culture or fish preservation involves at some stage of its progress the food of fishes. This, reduced to the ultimate end, centres around planktonic forms.

The realization of this fact has, within recent years, caused a considerable study of this phase of life. This is especially true in the case of the study of fresh-water organisms. Very little work on fresh-water biology has been done in British Columbia, except around a few lakes where fish hatcheries are located. It is fitting that a broader knowledge of the plankton forms of the fresh-water lakes in British Columbia should be had, both from an economical as well as zoological point of view.

It was with a view to studying fresh-water planktonic forms and observing their seasonal variation that Dr. C. McLean Fraser suggested that a survey of Florence Lake, Vancouver Island, be made as a fit and timely piece of research work.



Legend:

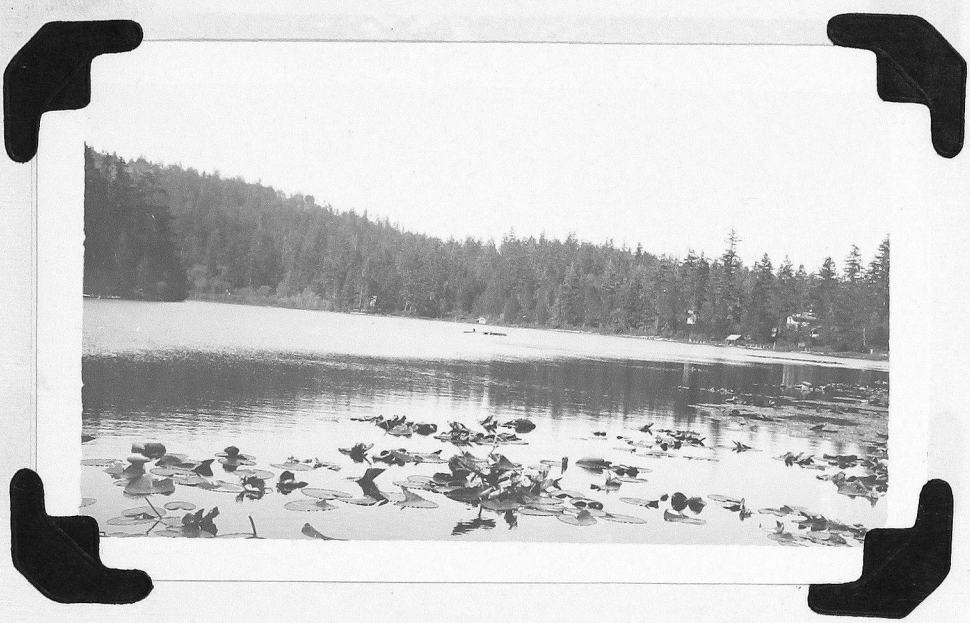
- Typha
- Marsh
- Station
- Nuphar
- B Brasenia
- L Ledum

FLORENCE LAKE

Contour Map

Scale. (Aprox.) 12" = 1 mi.

FLORENCE LAKE



Florence Lake - looking North

The East N.-East Shore.

East Shore - - Station-1

East Shore - - Central Region

South Shore. Station - 2

South-west Shore. Station-2 extends from area shown in the top photo to the spot x in the lower.

West Shore. Station - 3.

North End of the Lake. Station - 4.

FLORENCE LAKE

Location and Size.

Florence Lake is located ten miles W. N. W. of Victoria, B. C., at Latitude 48° 27'36'', Longitude 123° 30'45'' with an elevation of approximately 200 feet above sea level and about a quarter of a mile north of the Island Highway.

It occupies a small oval basin a quarter of a mile long and an eighth of a mile wide; bordered on the west and north by a hill of altitude 500'-600'; on the east by a rise of about 100'.

Marshy areas mark the north and south boundaries. The northern area, which is limited by the contour of the hill on that shore, dries up as the summer approaches. The southern area, which may extend as far as the Island Highway at flood water, in summer consists of a small pool connected with the south-east corner of the lake by a low depression; while the northern consists of a boggy area which dries up as the season advances.

During the winter a small stream, from a swamp two miles away, drains into the north-west corner of the lake. Due to the absence of an outlet the resulting rise in the lake level causes an overflow into the marshy areas described above.

It is quite probable that at one time Florence lake connected with Langford lake about one mile away

Contours and Depths.

The shore line is fairly regular. At the southern extremity two shallow bays are present, while at the northern a bend in the lake forms a third.

The greatest depth sounded was 20' (summer readings). The average depth was 12'-15'. The accompanying map will give an idea of the relative depths and general shallowness of the lake.

The western shore shelves most quickly, due to its bordering along the foot of the hill.

Extensive shallow areas of from 2'-4' extend out from the southern and northern shores to a distance of 50'-60'. At the southern end the depth is 12' about 100' from the shore; at the northern end it is approximately 6'. The shallow area here is probably greater than at the southern end for reasons to be suggested later.

In general the 4'-6' depth along the eastern side extends 30'-40' from the shore and is marked by the area of Nuphar polysepalum, which becomes wider at the northern and southern ends.

Ecological Zonation.

Florence lake may be considered as belonging to the third class of temperate lakes, viz., "Temperature of bottom water very similar to that of the surface water, circulation continuous except when frozen." (Welch.1935) It may be divided into the following zones.

1. The shore margin.

(a) Consisting of an encroaching area of Ledum

greenlandium. This extends from the north-west border, thinning out along the east-south-east border where a bank of rock slopes into the lake; widening again towards the east and south and becoming extensive along the south and south-west border. None exists along the west shore.

(b) A Typha area along the south-west margin, mingled to some extent with the Ledum.

(c) A rocky area along the central western shore with no marked characteristic growth.

2. The off-shore area.

(a) A mucky, rank-smelling ooze forming the lake-bottom in the Nuphar polysepalum area.

(b) A small area of Myriophyllum growing in black mud along the central region of the eastern shore.

3. Potamogeton Area.(Three species?)

This is found at the south-west and north-east corners of the lake and extends out beyond the Nuphar area to a depth of 12'.

4. A central area where the bottom of the lake is composed of ooze, mainly consisting of decaying plankton material and fairly rich in diatomaceous deposits.

In general the lake has the appearence of gradually drying up. The area of Ledum is gradually extending outwards, while the Nuphar areas, particularly along the eastern shore, are becoming smaller. This may be due in part to the exposure of the roots of many of them during the low water level experienced during the last few years.

It may also be partly due to the destruction caused by muskrats, which have been increasing in numbers and have been seen feeding on this plant. Along the central portion of this shore the Myriophyllum has likewise been subjected to similar exposure during the low water. Whether it will continue to grow under these conditions is questionable. It appears to be a favourite haunt of the black bass fry.

The Potamogeton areas were found beyond the realm of the Ledum and, in general, beyond the mucky ooze of the Nuphar area. Muskrats were seen towing strands of this plant across the lake to their dens at the south-west corner.

Brasenia, an indicator of soft water, (Ricker,1934), occurred in two localities, forming a fringe outside the Nuphar areas, namely along the south and north-east borders.

Some of the Nuphar was found to be growing at the edge of the 12' area.

Seasonal Changes.

Throughout the year the lake may have a rise and fall of 5'-7'. During 1933-34 the fall in level was over 5'; in 1934-35 a drop of over 6' occurred. This was the lowest level attained over a period of years.

Some idea of the rise and fall for the year may be obtained from the photographs of stations 1 and 2 which were taken in October, after the first rain when the lake

was almost at its lowest level. At station 1 the landing was 6" under water during the high water of the winter. At station 2 the lake level was within a foot of the landing.

In passing it may be noted that due to the presence of hills surrounding three sides of the lake the most prevalent wind is from the south-west. This is especially true during the summer when a strong breeze lasting an hour or two comes up in the morning about nine and again about four in the afternoon. This may, in part, account for the building up of the extended shallow area along the south-east.

RESULTS

The writer is well aware that many planktonic forms may remain at a depth beneath the surface of the lake and not be taken at the surface when hauls were made. These, if present, were neglected and comparative results were obtained of only those organisms which were taken at the surface, or showed a movement toward the surface of the lake at some time during the day.

Analysis of Plankton.

Arthropoda.

Insecta:

Chironomid larvae. Never very plentiful.

Chaoborus larvae. Seen during August and May.

Ephemerida. One seen from Station 2 in August.

Ostracoda.

No attempt was made to identify these.

Copepoda.

Diaptomus washingtonensis Marsh

Cyclops bicuspidatus Claus (Typical)

Cyclops phaleratus Koch Very few found.

Nauplii

Cladocera.

Alonella nana (Baird)

Bosmina longirostris (O. F. Müller)

" *longispina* Leydig

Ceriodaphnia lacustris Birge (?)

Ceriodaphnia reticulata (Jurine)

Daphnia longspina var hyalina Leydig forma typica.

Diaphanosoma brachyurum (Liéven)

Holopedium gibberum Zaddach

Pleuroxus denticulatus Birge

Malacostraca:

Hyalella azteca Saussure (vid. L. G. Saunders 1933

Hydracariña:

No attempt was made to classify members of this group.

Rotifera:

Asplanchna priodonta Gosse. Fairly frequent.

Chromogaster (Anapus) ovalis (Bergendal). Confused with Gastropus stylifer. More common than the latter in winter.

Colurella (Colurus) bicuspidata (Ehrenberg) Rare.

Conochilus unicornis Rousselet. Common.

Diurella procellus (Gosse). Rare.

" stylata Eyferth. Rare.

Euchlanis dilatata Ehrenberg. Rare.

Gastropus stylifer. Imhof. Common; disappears during the winter.

Keratella (Anuraea) cochlearis Gosse. Common.

" " quadrata (Müller). Fairly common in winter.

Lepadella patella (Müller). Rare.

Monostyla lunaris (Ehrenberg)

Monostyla bulla Gosse. Rare.

Notholca longispina (Kellicott). Never found in abundance. A summer form.

Notholca striata acuminata (Müller). Never abundant, a summer form.

Ploesoma truncatum (Levander)

Polyarthra trigla (platyptera) Ehrenberg

Trichocera cylindricus (Imhof)

Synchaeta sp.

Gastrotricha:

Although commonly found among water plants and ooze two specimens belonging to the genus Chaetonatus were taken in the plankton hauls for May.

Tardigrade:

Like the above group these organisms are to be found crawling among the debris and plant ooze of shallow water. Two specimens were taken in the hauls for June.

Protozoa:

Arcella vulgaris Ehrenberg. Present most of the year.

Arcella discoides Ehrenberg

Ceratium hirundinella (O.F.M.) Schrank.

Dinobryon sociale Ehrenberg (sp.?)

Epistylis sp. Ehrenberg

Mallomonas sp. Perty

Peridinium sp. Ehrenberg

Vorticella campanula Ehrenberg

Polyzoa:

Statoblasts of Plumatella (polymorpha?) were plentiful during December. Some were obtained up till April.

Desmidaceae:

Arthrodesmus Ehrenberg. Probably A. incus. Rare. Seen in May.

Closterium Nitzsch. Rare. Seen in early spring hauls.

Cosmarium circulare Reinsch (sp. ?). June, July, and August. More common in July.

Cosmocladium Rare. One or two specimens seen.

Docodium de Brébisson. Rare. Late spring and summer hauls.

Euastrum Ehrenberg. Rare. Seen in March.

Hyalotheca Ehrenberg. Spring and early summer. Never abundant.

Micrasterias Agardh. Two seen in June.

Sphaerozosma Corda. Common form throughout most of the year. Most abundant in early spring.

Staurastrum Meyen :

S. limneticum var. cornuatum G. M. Smith (1)

S. setigerum var. brevispinum (?) G. M. Smith. fairly common.

S. crenulatum Nageli. Fairly common in June.

Xanthidium Ehrenberg:

X. antilopaeum Kűtz. May and Sept.

X. subhastiferum W. West.

Both common though never plentiful.

Bacillarieae:

Asterionella formosa Hass. Tremendous bloom in December. Seen throughout the year.

Anomoeoneis Pfitzer (?). Small forms fairly abundant.

Cymbella Agardh. Very few seen.

Campylodiscus Ehrenberg. Seen in July 1934, and during the late spring of 1935.

Ceratoneis arcus (Ehr.) Kűtz. Peak appeared to be in August; seen throughout the year.

Fragilaria Lyngybe. Has a peak with Asterionella though never as abundant.

Meridion Agardh. Probably M. circulare (Grev) Ag. Common throughout most of the year, though never abundant.

Navicula Bory

Pinnularia Ehrenberg. Fairly common, though never abundant.

Stauroneis Ehrenberg. Commonest in December.

Tabellaria fenestra (Lyngb) Kütz. Most common in the spring, though never abundant.

Rhizosolenia criensis H. L. Smith (?). Recorded in July 1934.

Myxophyceae (Blue-green Algae):

Anabaena lemmermanni (?) P. Richter. Most abundant during June.

Aphanocapsa Nägeli. Most abundant in the spring and early summer hauls.

Chamaesiphon A. Braun and Grunow. These were found on algal filaments. Never plentiful.

Chroococcus Nägeli. Fairly common in spring.

Coelosphaerium Nägeli

Eucapsis Clements and Shantz. Fairly common in the summer, though never abundant.

Gloeocapsa Kützing. Abundant in early spring to summer. Present most of the year.

Gloeotrichia echinulata (J.E. Smith) P. Richter (?)

Lyngyba Agardh. Never very common.

Merismopedia Meyen. Not common. First observed in March. More abundant in May.

Microcystis (Clathrocystis) Kützing. Never as plentiful as Aphanocapsa. Rise in numbers from May to July.

Heterokontae:

Characiopsis cylindricum Lemm. (?) Found on copepods. More abundant in the summer.

Chrysophyceae:

Mallomonas Perty

Synura Ehrenberg. Not very common.

Chlorophyceae:

Ankistrodesmus Corda. Fairly common in early

spring.

Dactylococcus Nägeli (?). A specimen resembling this algae was found in May.

Dimorphococcus lunatus A. Br. One seen in May.

Eudorina elegans Ehrenberg. Most common in late spring and fall.

Elakatothrix Wills. Fairly abundant in March.

Gloeocystis Nägeli.

Golenkinia Chodat. Never very abundant.

Micractinium pusillum Fresenius. Peak in late win. (Richteriella Lemmermann) is a synonym.

Pediastrum Boryanum (Turp) Menegh. Never very plentiful.

Quadringula Printz. Incidental in appearance in the spring.

Selenastrum Reinsch. Rare. (?)

Sphaerocystis Chodat. Reaches a peak in early summer.

Spirogyra Link. Never very abundant. More in the spring and fall.

Volvox L. 1 specimen seen in March.

Zygnema Agardh. More seen in the winter hauls.

This list of organisms does not pretend to be a complete list of those present in the lake plankton. They indicate some idea of the variety present and the dominant forms.

Insufficient knowledge of algal classification prevented a complete analysis of all forms present in the hauls. The

one listed are those which were traced down with a fair degree of accuracy and certainty.

An analysis of the fauna of the lake bottom, the stems of the aquatic plants, etc., would probably add considerably to the present list to include tardigrades, tube-forming rotifers, insect larvae, turbellarians, and leeches. Such an analysis is beyond the scope of the present work.

The included tables show the counts for the various organisms over a period of one year. A study of them will give some idea of the seasonal variations that occur in the different groups. Graphs show the fluctuations of the more outstanding and important groups.

METHODS EMPLOYED

As pointed out by various workers on plankton organisms, no single haul from any part of a lake will give a representative sample of the organisms present.

Such ecological variation as is presented by the rocky shore on the west side of Florence lake and the oozy character of the remainder of the lake shore, suggested the possibility of some variation in planktonic forms. In order to test the possibility of such a variation hauls were made from six stations on the lake. This was for a twofold purpose; viz.

a. To determine if there might be some variation in the quantity of plankton from different parts of the lake.

b. To determine if there might be some variation in the forms of plankton from different parts of the lake.

Objections will be raised to the first on the grounds that the effectiveness of the net is not always the same and therefore some variation in efficiency might occur during the taking of the samples. To this it might be said that no dogmatic conclusions can be drawn from the figures in the results but they merely suggest some idea of the relative quantity of the various organisms from the different stations. No net apparently, is more than 40% efficient. This will vary with the quantity of plankton present and the distance through which it is hauled.

Further, the volume of the water passing through the net was not determined but a definite distance for each station was chosen through which the net was drawn. Here, again, a

better idea of relative quantity of the organisms might have been obtained if the length of the hauls had been made the same for all the stations. Comparisons showing relationships can possibly be made by bringing the results obtained to a common factor; namely, making each station a distance of 500 feet. There are objections to this that by increasing the hauls in this manner, the source of error is also increased.

Light as a distributing factor was taken into consideration by taking hauls from the same stations at different times of the day.to determine the possibility of a suggested correlation between the number of organisms present and the amount of light. No attempt was made to measure the amount of light at any time or the depth of penetration into the water of the lake. A statement is made of the presence or absence of sunlight, shadows, or moonlight.

Surface hauls were made once a month over a period of one year (1934-35) from six stations on the lake. Due to unavoidable circumstances no hauls were made in September 1934. During January 1935, the freezing over of the lake prevented the taking of any hauls.

In making the surface hauls a six inch diameter net of #25 bolting silk to which was attached a 20 c.c. vial, was towed from the back of a slowly moving rowboat. The sample thus obtained, was allowed to settle and then reduced to a 10 c.c. volume. A few drops of formalin was used as a preservative.

It is quite probable that a larger net might have been

used to advantage. Realization of such a probability did not occur until the work was too far advanced to change the pro/cedure.

A vertical haul was made to see if any organisms not obtained from the surface were present between the surface and the bottom of the lake. Here, in particular, a larger net would have been of advantage.

Stations and Hauls Made from Each.

Surface hauls were taken once a month at noon and evening from Stations 1, 2, 3, 4, and 5. In addition to these a midnight haul was made once a month from Stations 2, 3, and 5. A vertical haul was made once a month from the centre of the lake (Station 6).

Length of Hauls.

Station 1. 250' along the east shore at the southern end outside a reedy area.

" 2. 400' at the southern end along the outside border of a lily bed and above Potomogeton.

" 3. 450' along the rocky west side of the lake.

" 4. 300' at the southern end of the lake above a bed of Potomogeton, outside a reedy area which merged into an area of water lillies.

" 5. A 560' tow from the centre of the lake.

" 6. A vertical haul from the centre of the lake.

Methods Employed in Making Counts.

An examination of the 10c.c. haul was made in a 10 cm. diameter petri dish under a binocular microscope (32mm. obj.

x6 eyepiece) to determine the presence of the crustacean forms and the larger rotifers. For making the counts a 1 c.c. cell marked off into 1/15's of a c.c. was used. This was similar to the cell used by Birge and Juday. Counts were made under the 16mm. objective of a monocular fitted with a mechanical stage. A total count of all the crustaceans, Asplanchna, Synchaeta, incidental rotifers; e.g., Colurella, and the larger algal groups; e.g., Anabaena. One-fifth of a c.c. was used as a unit volume to be counted for all other forms. The total counts were recorded as the number present in 1 c.c. of the original 10c.c. volume of plankton obtained from the tows over a distance of 500'. Wherever the haul made was less than 500' the count of the organisms in that haul were multiplied by the factor of 500 that would make the length of the tow for that station equal to 500.

Whenever the quantity of plankton made a 1 c.c. count of the 10 c.c. volume impossible, the total volume was made up to 20 c.c. and results recorded as numbers present in a 1 c.c. sample of the original 10 c.c. volume. i.e., multiply the Cladocerans by 2, the algae by 10.

During December a bloom of Asterionella necessitated a 40 c.c. dilution of the original 10 c.c.'s for the making of the algal counts. The Crustaceans were counted from a 20 c.c. dilution. This was done to give more accuracy to the count of the small algae which would otherwise have been masked by the large quantity of Asterionella.

Objection will probably be raised to the use of these dif-

ferent dilutions on the basis that they do not give sufficiently correlated comparisons. A relative comparison can still be made. As stated previously, the figures for the numbers of each group present are intended to show relative frequency not exact number of organisms present. Such a result is impossible when dealing with a nomadic population. A general cross-section of the lake population is all that can be hoped for.

It is obvious that this method of counting might give too great a frequency in some cases to the "incidental organisms"; e.g., Euchlanis, but at the same time too small a proportion would be given to the small algal forms masked by the bloom of Asterionella and Peridinium.

Such difficulties as these are always present and seem unavoidable.

The rotifer counts presented some difficulties due to unfamiliarity with the group and the impossibility of using the high power (1.6mm.) objective of the monocular microscopewith the counting cell employed. For this reason a very small rotifer was observed which could not be identified. A count and recording of it was made as an unidentified rotifer. Forms such as Asplanchna and Synchaeta were distorted in many cases by the preservative so that accurate determination of these could not be made, when such forms were met with. The trochal disc and foot in many of the Synchaeta were withdrawn giving the larger ones the appearance of Asplanchna. It is very probable that the majority of such forms seen during February were Synchaeta as this rotifer

has a sudden bloom during this period (Lotka 1925)

Chromogaster ovalis was at first confused with Gastropus stylifer. It is therefore included in with the counts of the latter and reference made as to which is the predominant form.

By the above grouping of the rotifers it is possible to give the relative variation in the total rotifer population and an idea of the variation (with the restrictions noted above) in the population in each group throughout the year.

Groupings of the Algal Forms.

The groupings employed were to facilitate counting and included forms of general similarity of make-up. The same forms were included in each group throughout the year; any "incidentals" which might have warranted inclusion in one of the groupings employed was recorded separately. A record was made of the "dominant" form in any group and the relative proportion of the others. In the colonial forms the average number per colony was also recorded.

The following headings with their inclusive forms was employed.

Gloeocapsa - (Blue-green Algae)

Chroococcus Nägeli. Dominant during March; continued till the Fall.

Gloeocapsa Kützing. Dominant during the Summer.

Eucapsis Clements and Shantz. Present in Summer

Aphanocapsa -

Microcystis Kützing. (Clathrocystis Henfrey)

Most abundant in June.

Aphanocapsa Nägeli. Most abundant in June.

Merismopedium Meyen. Never very abundant. Began to appear in April.

Coelosphaerium Nägeli. Confused with regularly formed colonies of Aphanocapsa.

Micractinium Fresenius (Richteriella Lemmermann)

Selenastrum

Selenastrum Reinsch, Rare. (?)

Ankistrodesmus Corda. Few of this form were seen.

Quadrigula Printz. Probably the most common form.

Elakatothrix gelatinosa Wille. Sporadic in appearance.

Sphaerocystis Chodat (Eutetramorus Walton)

Sphaerocystis Chodat

Gloeocystis Nägeli

Several small green algae were included, but the quantity of Sphaerocystis was always noted.

Most difficulty occurred in the placing of the unicellular green algae. Some of these may have been included among the Gloeocapsa group in spiteoof care to try to keep them in the Sphaerocystis group.

Diatoms and Desmids.

No attempt was made to make separate counts on the numbers of the different genera present. The dominant form in each maonth was recorded. In the case of Asterionalla an attempt was made to give some idea of the number present.

Protozoa.

Vorticella. This was counted in relation to the numbers present on the colonies of Anabaena, where it was most frequently found.

DISCUSSION OF THE RESULTS.

Bottle X 15 for March from Station 1 and bottle X 31 for May from Station 5 (centre of the lake) were inadvertently broken. No counts of these could made.

No readings for temperature, pH, acid carbonate or light penetration weretaken. Certain features regarding the results can be indicated only. Therefore, any suggestion as to "why they are so" is suppositional, needing further work to reveal correlation between the above mentioned factors and the plankton population.

As stated previously the purpose of this work was first to show the seasonal variations occurring in the plankton; secondly to show, if possible, any diurnal movement of the organisms that takes place; thirdly to show variation in quantity for the various parts of the lake. In these matters the results speak for themselves. In taking these results it should be borne in mind "no two taken with the same organisms present will show the same reactions of those organisms to their environment." (Welch, 1934)

It is therefore the object now to analyse the results as far as is possible from the data to hand and compare wherever possible with data from other lakes.

Crustaceans.

The total crustacean population reaches a peak in spring and autumn (Pearse, 1926). From the results one would say autumn and early spring with a higher peak in the latter.

Ceriodaphnia reticulata. (Jurine)

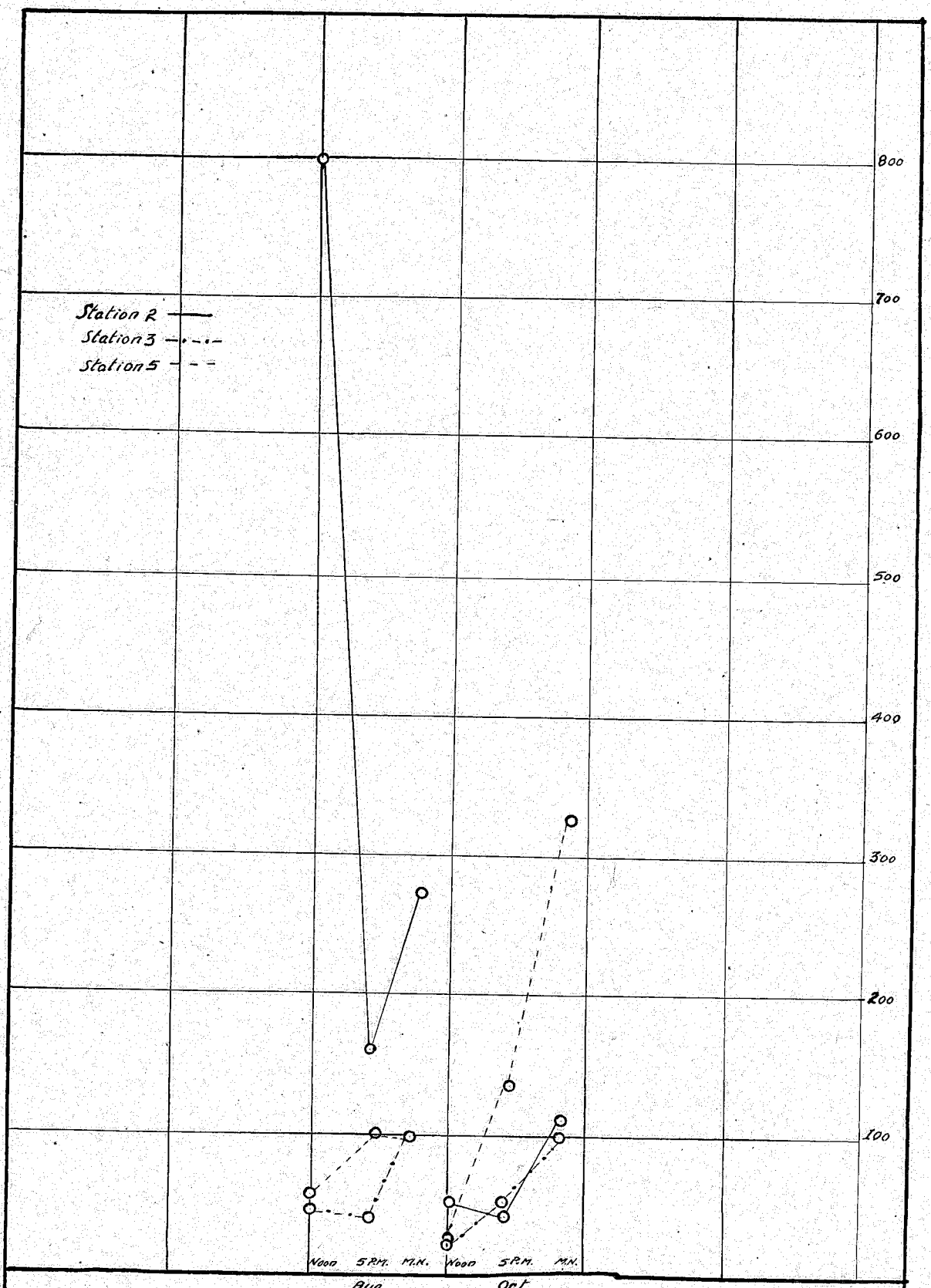
This species shows a decided peak in its occurrence from August to October with an indication of its presence in late July and early November. No hauls were taken during September but it is permissible to surmise from the results that the peak of its numbers would be in September. The forms taken during August were mainly of young individuals. Foerster (1925) reports this form to be found as early as June, but no individuals were taken from Florence lake so early in the season.

A variation in its numbers during the day is shown. An examination of the hauls from all stations shows a decided increase toward midnight after 5:00 p.m. During August the greatest numbers were found at Station 2. The numbers showed a decrease at the 6:00 p.m. haul and an increase at midnight. The haul from the centre of the lake showed an increase between the noon and the 6:00 p.m. haul. The same occurred at Station 4 at the north end of the lake.

Since the greatest numbers during August were found in the vicinity of Station 2 it is probable that this shallow weedy region was a breeding area or offered a rich food supply. Their distribution throughout the lake may be explained by the following:

About four o'clock in the afternoon a strong breeze rises and blows across the lake from the south-west to the north-east corner of the lake. This would probably cause a scattering of the organisms from the south-west corner to-

Graph – 1



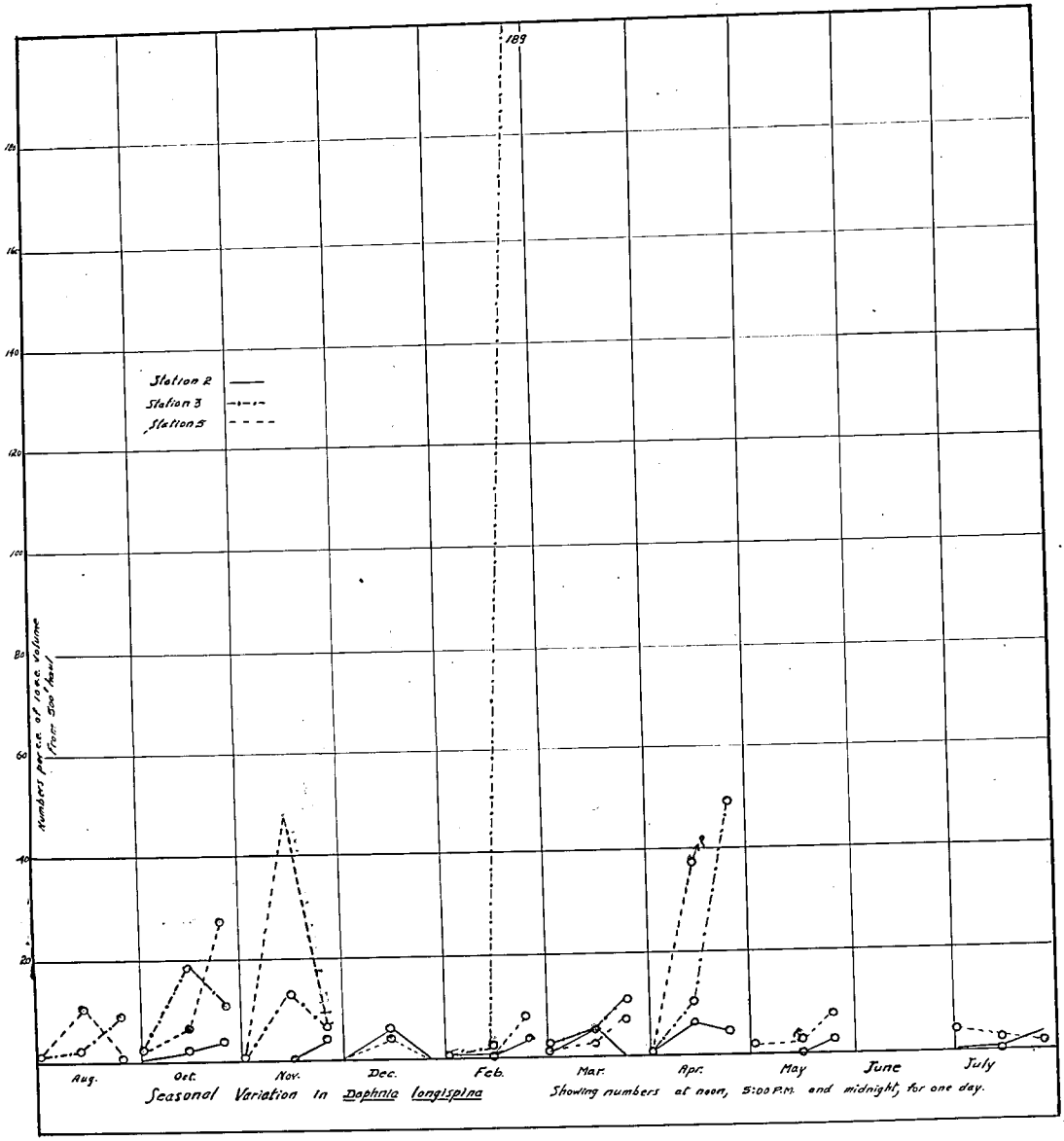
Variations in Ceriodaphnia reticulata

Numbers per c.c. from 10 c.c. volume.
Counts of hauls from 3 tows taken in one day.

wards the north-east with the density of the population thinning towards the latter part of the lake. (Welch 1935) "In general, horizontal distribution of plankton and alterations in it are largely af a mechanical character and less concerned with profound environmental differences such as are involved in the vertical distribution."

The hauls made in October were during a calm day. The general trend of the graphs is a steady rise till midnight. This would suggest a nocturnal movement with a possible indication that the adults prefer the deepre waters of the lake, at least during this month. Such a concentration in the centre would then be explained by Welch (1935), "Plankton which migrate vertically descend with the onset of dawn, those nearer the shore arriving at the bottom at a higher level, and, following the slope of the basin in order to reach deeper water, tend to concentrate in the depths; on the next trip to the surface they rise vertically from the profundal area, thus producing at the surface a greater concentration above the deep parts than above the peripheral regions." (Graph. *1*)

Daphnia longispina var. hyalina Leydig. Of this species in Cultus Lake Ricker (1934) says, "It is a warm-water species abundant from May to October. The preponderance of the form found in Florence Lake is toward the winter months; that is, from Nov. to April. This might be explained by an accumulation of Daphnia in the lower stratas of the lake during the summer months and rising to the upper strata during the winter



Seasonal Variation in Daphnia longispina

Showing numbers at noon, 5:00 P.M. and midnight, for one day.

Graph 2.

months. In the majority of the hauls a general tendency to rise to the surface at night is indicated during the summer. During October, November and December there is some indication in the colder regions of the lake of a rise during the afternoon and a settling beneath the surface during the night. The haul along the rocky shore during October and that from the shallow reedy portion at Station 2 appear to be exceptions. Aside from currents that might explain some of the exceptions that of Van Cleave (1924) might be added (in regard to Cladocerans) "Most react positively to weak light and negatively to strong. This may be reversed by other stimuli acting as controlling factors. In cold water they may act positively to light stimulus which would repel in higher temperatures." Could it be possible that the cold water during the winter months caused a negative tropism to light? Certainly in December the lake was frozen and during the winter months the rocky shore receives very little direct sunlight.

Welch (1935) quotes from other sources, "In a typical temperate deep lake it commonly behaves as follows: both young and full-grown individuals spend the after part of the night near the surface but descend during the day into the depths remote from the surface. ---in Lough Derg, Ireland, the young of D. longspina have the usual migration,- strangely enough the adults perform a reverse type of migration. It appears that the various forms of D. longispina, of which there are many, may differ in migration behaviour; for

example, it was found that in a certain Wisconsin lake- the form having rounded crests or helmets did not show diurnal movement, while that form with pointed crests showed such movement; in another lake containing both forms, the migration behaviour was exactly the reverse; in still another lake containing both forms, both manifested diurnal movement."

With regard to the different forms of D.,longispina it is interesting to note that during July 1934, the form found was D. longispina var. hyalina. As the season advanced a change was observed in the general form - a sharper curvature of the head. This decreased toward the next summer. Again, during June of 1935, the decided mendotae and galeata forms were found. Many, during June and July, particularly from centre hauls had a coronet of three or four spines on the head. This form was seen by the author in one pool in the Tranquille lake region.during July 1935. At least one individual in the July haul from Florence lake had a decided depression on the curve of the crest in which was found a blunt projection. If the various forms have different migratory periods and may inhabit different parts of the lake, to which may be added a reversal in movement due to seasonal variations, there is some reason for the irregularity in the readings. Whether the forms noted were seasonal variations of the same form or variations in the forms of different races is a problem for further study. Woltereck and Wesenberg-Lund are doing considerable work on this matter and have yet to arrive at a conclusion satisfactory to both parties.

Bosmina - According to a chart by Worthington (Welch 1935) the adults and young of Bosmina show a decided variation in behaviour. The adults remain near the surface throughout the day, whereas the young descend to the depths during the bright sunlight - descent beginning with the sun lighting up the water. This would imply that in those section of the lake on which the sun can shine most of the day and which are inhabited by Bosmina - little variation in the numbers caught would occur during the day. An increase in numbers would take place when the sun left the lake in shadow and the young began to migrate to the surface. In general, this appears to be the case with the numbers of Bosmina obtained from Florence lake. During November the presence of a wind may have heaped up the extra amount of Bosmina on the west shore (Station 3)

Pleuroxus denticulatus Birge, Chydorus sphaericus, Alonella nana (Baird), and Holopedium gibberum Zaddach appear tobbe incidental plankters of Florence lake, though the first and last are reported from some lakes as being plentiful. Pleuroxus and Holopedium appeared more during the summer, while Chydorus and Alonella were of more common occurrence during the winter and early spring, though some of them were found in June. Insufficient numbers were obtained to draw any conclusions regarding their movements, though Pleuroxus would appear to be at the surface during the day and descend during the night.

Diaphanosoma brachyurum (Liéven).

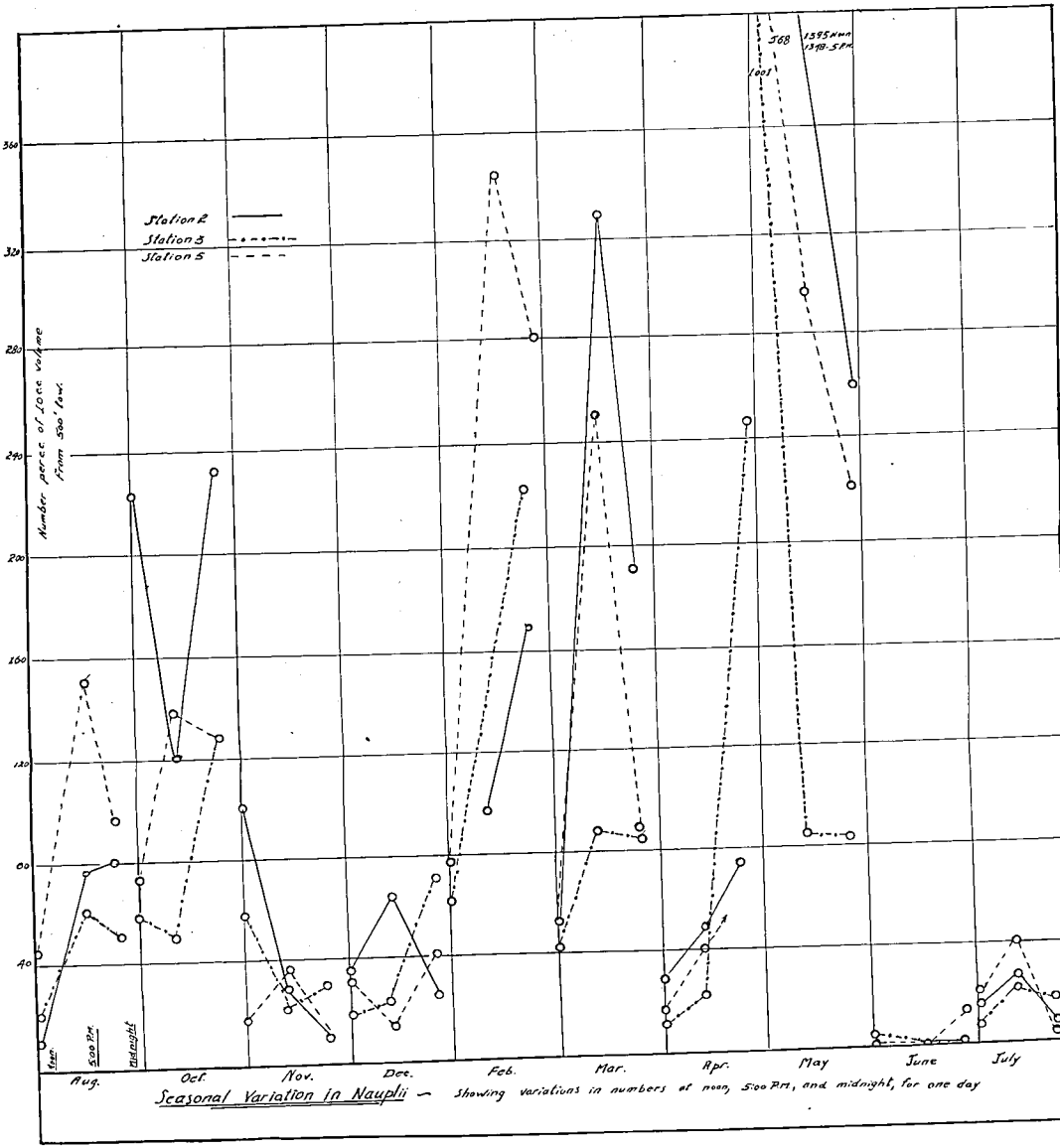
(Welch 1935) Diagrams from Worthington would show a slight sinking of this organism during the day. This is scareely so by the results obtained from Florence lake, but the numbers are not large enough to be of much significance. The two stations with deeper colder water show a reversal, namely, more in the morning and less toward night. It was never very abundant but seems to overlap into the beginning of the Ceriodaphnia bloom. Eddy (1934) describes it as a Serotinal predominant - that is, an organism present from July to September, which correlates with the results obtained as far a seasonal occurrence is concerned, but it is by no means a predominant in Florence lake.

Diaptomus washingtonensis Marsh.

This form was never very abundant. This might be expected as most species of Diaptomus inhabit deeper waters and the tows taken were from the surface. (Welch 1935 and Foerster 1925). Insufficient numbers were obtained to draw any conclusions regarding its migrations. Welch (1935) quotes that the adults show a slight diurnal movement to the depths, while the young show a decided migration of a similar nature. During February and March females with eggs were observed, during May and June many of the individuals were young, this was particularly so in the night hauls. The greates numbers of adults were obtained during November and December.

Nauplii.

From a study of the graph from Stations 2,3, and 5 it will



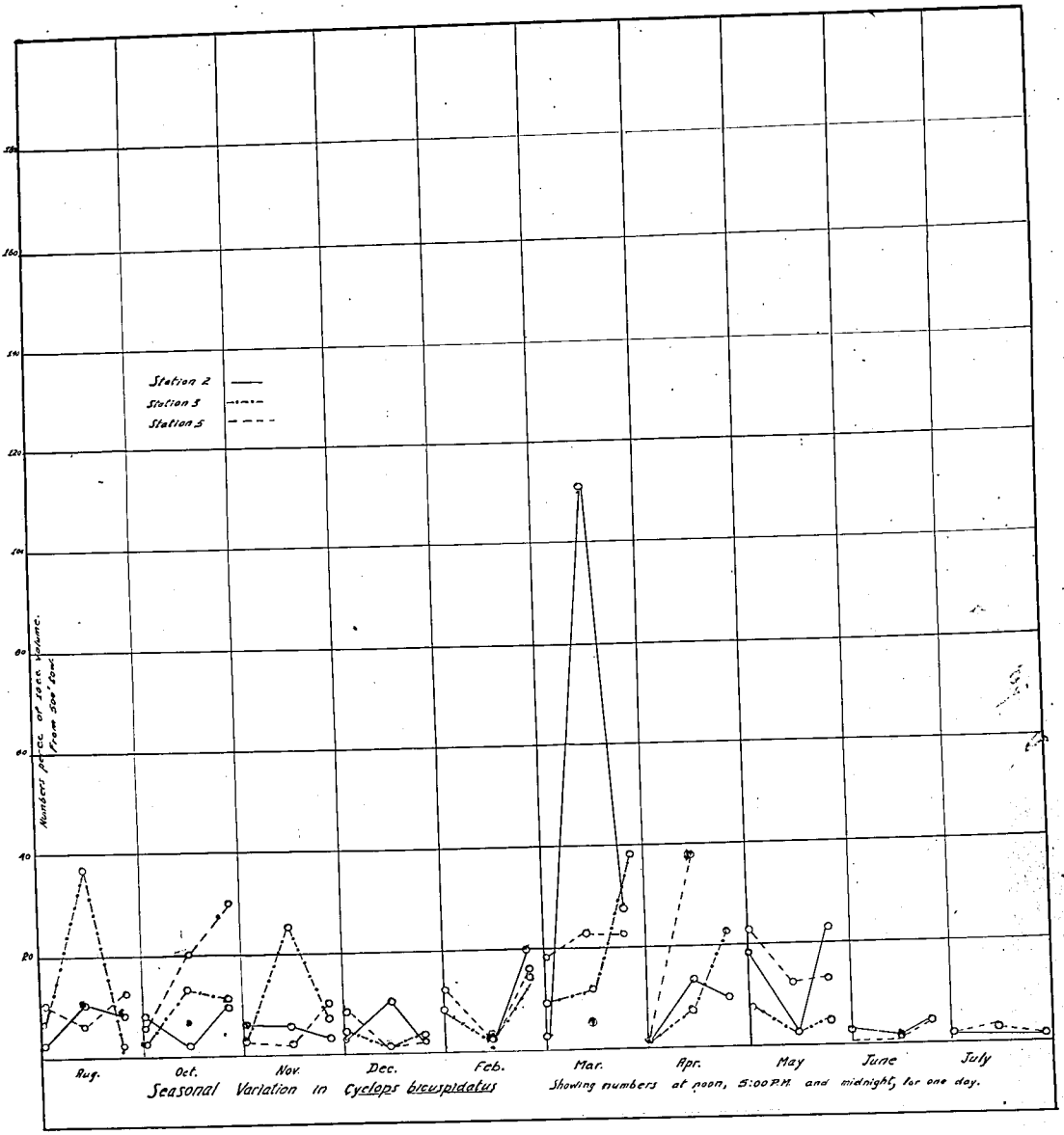
Seasonal Variation in Nauplii — showing variations in numbers at noon, 5:00 P.M., and midnight, for one day

Graph-3.

be seen that the abundance of nauplii varies greatly with the season. A high peak in August and October is followed by a fall in numbers during November and December; this is succeeded by a high peak in February and March. A fall off occurrs in March to be followed by the highest peak of the year during April and May. A minimun occurs in June followed by a rise during July. There are, then, three peaks throughout the year beginning at August, with each successive one greater than the one before.

That diurnal variations occurs is evident, but correlation was not obtained throughout the year. Several reasons for this might be suggested, such as variations in temperature in the different parts of the lake, light effects in the different parts of the lake, and what is most probable, the presence of different types of nauplii. Nauplii of one form may be more abundant in one part of the lake than another and have a different period of migration than the nauplii of another form. That is, nauplii of Cyclops bicuspidatus could have a different migration to Cyclops phaleratus; these in turn might vary from that of the nauplii of Diaptomus washingtonensis.

Correlation was obtained from March to July. During March a rise from noon till 5:00P.M. occurred followed by a descent to deeper waters. This is similar to the graph for August. In April a continued rise till midnight occurred. During May there was a peak at noon followed by a continued descent throughout the rest of the day.



Seasonal Variation in Cyclops bicuspidatus

Showing numbers at noon, 5:00 P.M. and midnight, for one day.

Graph 4.

Cyclops bicuspidatus. Claus

Two peaks occur, a low one in August, September, and October, and a high one during the period of spring maximum in March. (Graph 4) Correlations in migration from Stations 2, 3, and 5 were obtained for the months of February, May, June and July. A movement to the depths from noon till 5:P.M. is indicated with a rise to the surface again at midnight. The other results do not correlate. The cause for this may lie in the reason suggested for the movement of the nauplii. Cyclops phaleratus was noted in the lake. It may have had a different mavement to C. bicuspidatus. Its occurrence was more frequent in the fall than in the spring. Before any assertion can be made regarding its movements, a check-up will have to be made.

Hyalella azteca Saussure.

This was found in large numbers in the lake. It was found in the plankton at nightfrom June to August. It appears to be heliophobe, preferring the dark shadows of the Nuphar areas in shallow water during the day, but found throughout the waters of the lake after dark. One specimen was found inthe centre of the lake during the day, but in general, the above statements regaring its behaviour stands. Rawson (1934) to few being found below 10 metres. Ricker (1934) shows that during the winter these frequent the shallow edges of the lake inhabiting water between 1 and 2 feet.

Rotifera.

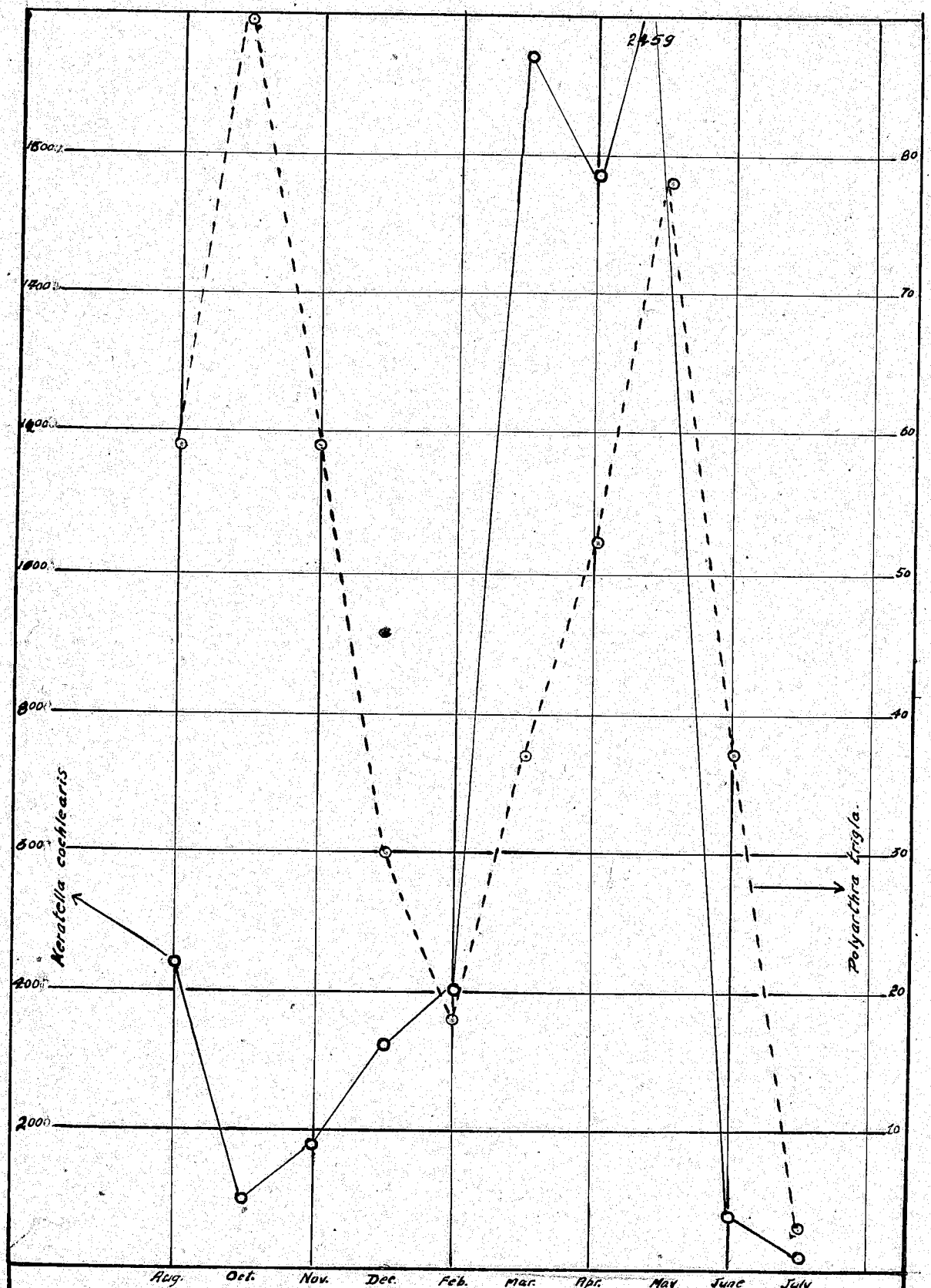
The lake possessed a rich fauna of rotifers. These showed seasonal periodicity and fluctuation in numbers. For example, Asplanchna priodonta Gosse, was more common in the summer, though never abundant at any time. Notholca striata and Keratella quadrata (Muller) were found during the early spring and winter.. K. quadrata rose to its greatest abundance during February. Eddy (1934) classifies K. quadrata and N. striata as vernal predominants, occurring from February to June. In Florence lake they were found from December till March. At no time were they very abundant.

Synchaeta showed a predominence in the spring and fall. There may have been two species present as the forms were not specifically determined and there was some indication of there being two species in the lake. Synchaeta is one of the forms listed by Eddy as being a "Perennial Predominant". Lotka(1925) refers to the bloom of Synchaeta in early spring.

Trichocera cylindricus (Imhof) (Rattulus) rose to a peak between August and October with indications of its presence in July and November

Such forms as Monostyla , Diurella, Lepadella patella (Meller), Diurella, and Colurella were incidentals. They were never present in sufficient numbers to determine a seasonal variation. It would appear that Colurella is an autumnal form, though verification of this would need to have further study.

Graph – 5.



Seasonal Variation in Rotifers.

Numbers per c.c. from 300 c.c. volume.
Average number per day from Station 3.

The dominant forms were Polyarthra trigla Ehrenberg, Keratella cochlearis Gosse, Gastropus stylifer Imhof, and Conochilis unicornis Rousselet. Gastropus stylifer was confused with Chromogaster ovalis (Bergendal) which occurred in greater numbers during the months of December, February, and March. Gastropus stylifer reached a peak during October. becoming negligible during the winter, increasing slightly during June. There is some indication of a variation in numbers during the day and night. This may be due to temperature, wind currents or other factors already discussed, as well as depth of water. No correlation is shown from station to station.

Keratella cochlearis is said to show diurnal fluctions. Whether one is justified for assuming this to be shown by the results is doubtful. Seasonal fluctions in numbers is shown and some variation in form was noted; e.g., larger size of the animal and greater prominence of the spines during the winter. The peak of its numbers as shown in Graph 5 bear some resemblance to a graph in Eddy (1934) but any statement regarding the exact limits of these peaks cannot be made for the periods of its peak and the height of the same vary from year to year. This statement applies to all the other planktors dealt with. Some forms may rise to greater prominence one year than during another. How such cycles run calls for a great deal more observation. K. cochlearis in greatest numbers at Station 2 in the reedy section of the lake. Foerster (1925) reports a similar predominence in

shallow water. They were not found in the shallow north end of the lake in such large numbers.

Conochilus unicornis was found in greater numbers from Station 5 in the centre of the lake than at the shallower Stations. This agrees with Foerster's observations that it is found in the deeper regions of the lake in greater abundance than elsewhere.

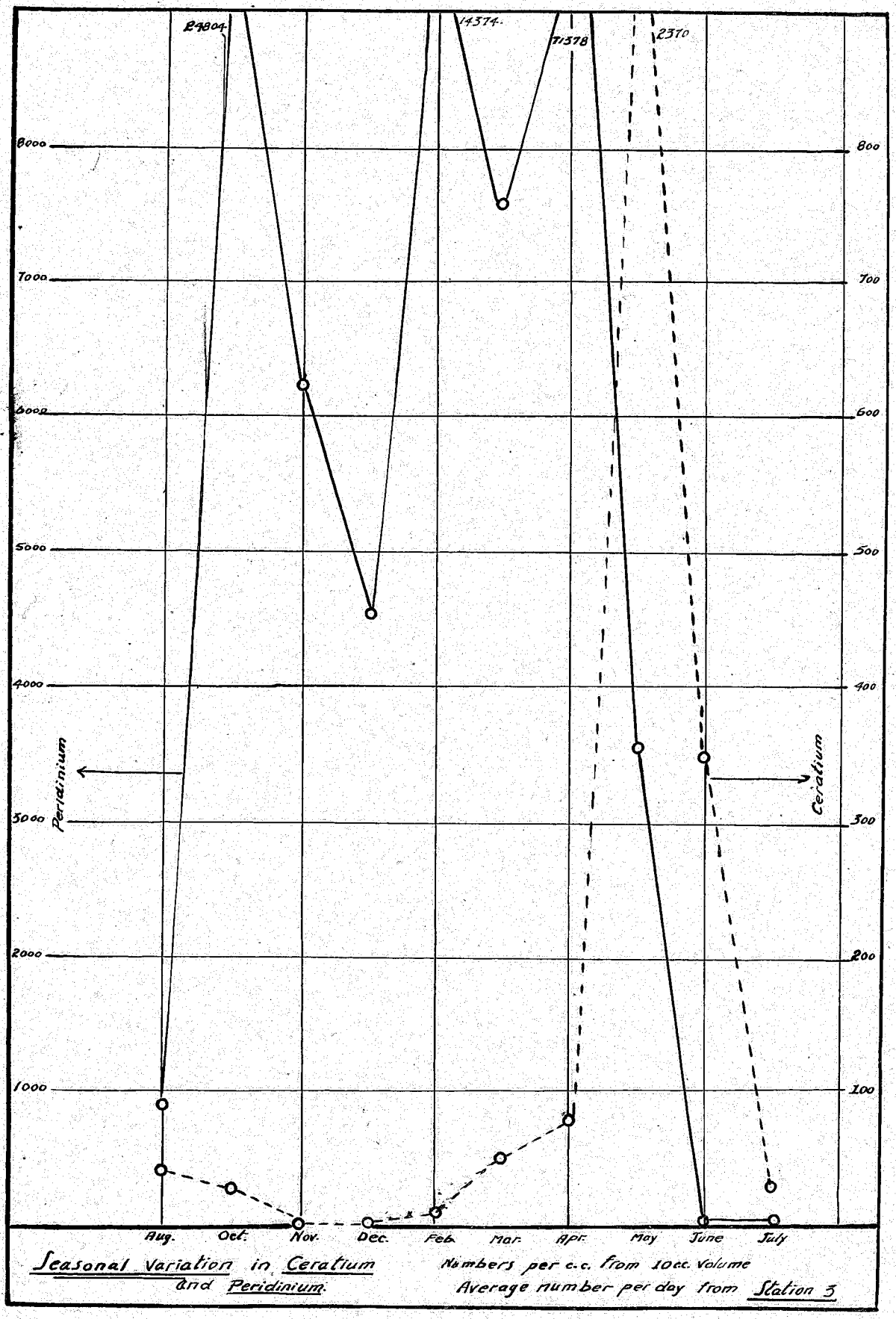
Protozoa.

Arcella - was present in most of the hauls. More were obtained from the shallower Stations than from the deeper. This is as would be expected from its habits of growth. Predominence was during the fall and spring.

Ceratium hirundinella (O. F. M.). The form, if the same species was present throughout the year, took seasonal variation. Welch (1935) reports such a change occurring. The general shape during the winter months was more compressed than during the summer - the arms gradually spreading out from the winter form till that of the summer was attained. A small peak occurred during the fall but the organism disappeared during the winter. A gradual increase took place during February, this continued till a peak was reached in May after which there was a steady decline as the summer advanced. This organism, apparently, is more numerous in surface hauls (Foerster 1925) particularly in shallow water similar to that in which Arcella was found most abundantly.

Dinobryon sociale(?) Ehrenberg. During July 1934, this organism reached a very high peak. A sharp fall off in

Graph – 6



Seasonal Variation in Ceratium and Peridinium.

Numbers per c.c. from 10cc. Volume
Average number per day from Station 3

August followed. During October there was a slight increase in numbers, but from then till February there was practically none found in the plankton. A sudden increase occurred during February rising to the highest peak of the year in April. During May there was a mere indication of its presence, this was followed by an increase in June. There was a mere indication of its presence in the hauls for July. July 1935 was therefore, quite different from July 1934 as far as the counts for Dinobryon are concerned. This variation in the palnkton from year to year is to be expected as food, weather conditions, ecological factors in general vary from year to year. (Eddy '34

Vorticella. This organism was counted in its relationship to Anabaena and therefore its prevalence follows that of Anabaena, namely, a peak in June and August, the June peak being the higher.

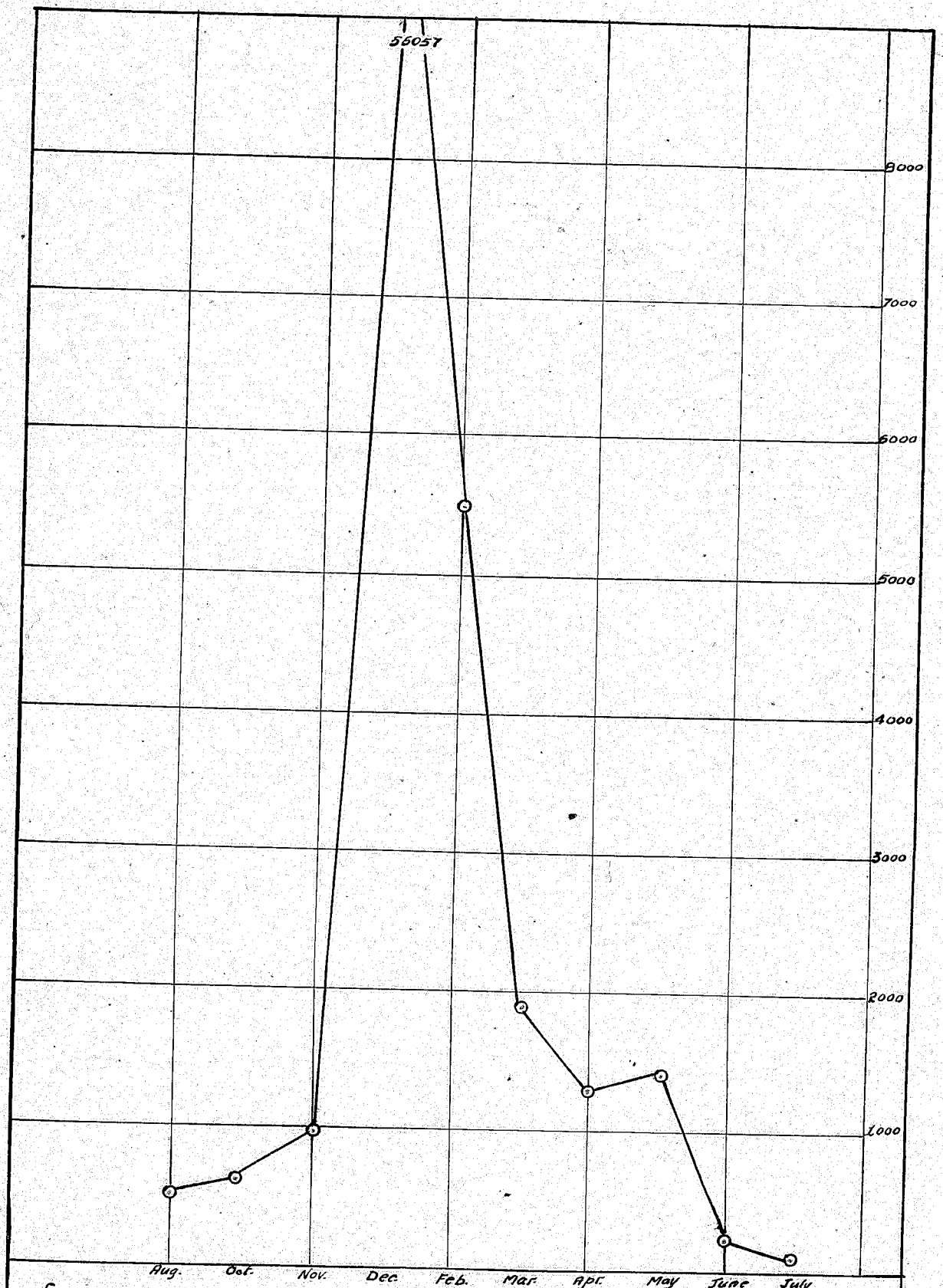
Peridinium. was encountered in great numbers during October, November, and December, the highest peak occurring in November. A higher peak occurred in April, after which it disappeared during the summer. Yonge (1928) refers to the summer decline of Peridinium in the following," Exhaustion of the phosphates is as important as nitrogen as a cause of the summer decline of diatoms and Peridinium." (Ceratium also?)

Difflugia and Epistylis were incidentals.

Algae.

With regard to the general occurrence of the algae the following is a free-quotation from G. M. Smith, 1935.

Graph 7.



Seasonal Variation in Diatoms

Numbers per c.c. from 10 cc. volume.
Average number for the whole day. Station 3

"Blue-green algae usually occur in abundance only during the warm months of the year, but certain species may develop in quantity during the winter;e.g.,Gomphosphaeria. (This genus was found in Florence during February.) Soft-water lakes ordinarily have more Chroococcales than other Myxophyceae but these never predominate at any season of the year. Chlorophyceae is rarely a predominating organism in the phytoplankton of lakes and ponds, the number of species found in the fresh-water plankton is very large. As a general rule they are most abundant in late spring and early autumn."

Anabaena. Two peaks were noted;one in the fall, the other in early summer. It is called an Estival by Eddy (1934) as it occurs from March to December. In general this statement holds true for its occurrence in Florence lake.

Diatoms. Two peaks were noted; one in the fall, the other in spring. The spring peak being the higher. A bloom of Asterionella during December and lasting till February, is worthy of note. This diatom pollutes the water giving it a decided odour. (Whipple 1927). The various forms found and their occurrence has already been noted in the list of the organisms found in the plankton.

Aphanocapsa Group. As stated previously this group included several algae. Microcystis was found fairly abundantly in the fall and spring, making its appearance in April and rising to form approximately one-sixth of the total number of this group during the beginning of June. A fall in

the numbers of this form was noted during the summer. Aphanocapsa and Coelosphaerium also increased over the same periods as Microcystis.

Desmids.

These were never present in large numbers. In the mossy areas near shore many of the large forms such as Micrasterias Euastrum, Cosmarium and Closterium were found. The odd individual of these forms was found in the plankton. Acidity (G.M.Smith 1933) appears to be needed for their development. A fall in numbers is noted after May. No definite statement can be made regarding its movements or localisation in any one part of the lake.

Gloecapsa.

Like Aphanocapsa this group included several organisms. Of these Chroococcus was more abundant than the other forms during March. This form continued till the fall. This period of growth agrees fairly well with Birge and Juday's chart (Welch 1935). No definite statement can be made, as the period of growth is regulated by factors variable from year to year. Gloeocapsa appeared later than the former and became more abundant during the summer. During April a period of rapid cell-division appeared to have occurred throughout all the algae forms, but especially in the blue-greens.

Sphaerocystis.

The cycle appears to be as follows: and autumnal increase over the summer population; a disappearance during

the winter; a rapid increase during April; a decrease in June, followed by a rise in July. This is also fairly well represented in Birge and Juday's chart of seasonal changes of form found in the plankton of Lake Mendota. Gloeocystis would appear to have a similar cycle.

Richteriella.

Counts were not taken of this organism for the whole year. From those taken a decided peak is shown during the winter months. Whether the apparent correlation of greater abundance at noon of the plankton than at midnight throughout the majority of the hauls is significant cannot be definitely said, but light would be necessary for photosynthetic processes and the organisims might in some manner be attracted to it.

Selenastrum.

This group included several similar forms. Its periodicity is shown on the charts - there is a small peak in November, followed by a complete disappearance in winter. A sudden bloom occurs in April during the period of rapid proliferation of all the algae.

SUMMARY

1. A survey of the general ecological features of Florence lake was made.

2. Difficulty is ascertaining certain genera under the 16mm. objective necessitated the combining of some of the smaller algal forms into groups. This did not prove very satisfactory in giving the periodicity of members of the group but served to show fluctuations of the group as a whole.

3. Seasonal variations of all the organisms observed was found. The indicators of the seasons are listed below.

Perennial forms. The following were present throughout the year. Periods of abundance are noted for each species.

Bosmina longirostris. Abundant from August to October.

Keratella cochlearis. Abundant in the Autumn and Spring.

Most abundant during the Autumn. (Graph 5).

Polyarthra trigla. Most abundant during the Autumn.

(Graph 5)

Peridinium. Most abundant in the Autumn and Spring.

(Graph 6)

Hiemal forms. (December to April).

Asterionella formosa. Peak in December.

Richteriella. Peak in December.

Keratella quadrata. Peak in February.

Selenastrum. Peak in April.

Vernal forms. (February to June)

Notholca striata. (Incidental in appearance from Feb-

ruary to March.)

Estival forms. (March to December)

Daphnia longispina. Peak from February to April. (Graph 2)

Asplanchna priodonta. Incidental in occurrence.

Anabaena. Peak in June.

Conochilus unicornis. Peak in august.

Serotinal forms. (July to August)

Diaphanosoma brachyurum. Peak in July.

Ceriodaphnia reticulata. Peak from August to September.

Rattulus cylindricus. Peak in September.

Ceratium hirundinella. had a very high peak during May and a lowere peak during August. It was not observed during the winter from November till February.

Dinobryon. occurred in very large numbers during May and October. From November till February it was not seen to any extent in the plankton.

4. Indication of diurnal movements in some of the groups is shown; e.g., Nauplii, Cyclops, Daphnia and some of the rotifers. Correlation, from all sedtions of the lake, of such movements was not obtained. This may have been due to one of several ecological factors other than light acting on the organisms; e.g., wind currents, or it may have been due to error in making the hauls.

5. Charts were made showing the numbers of organisms

found at each station throughout the year. Graphs were constructed showing the fluctuations in the representative organisms throughout the year.

6. The of large quantities of certain organisms in the lake explained the presence of a distinct odour and tainted taste present in the water. A list of the organisms and the odour given by each, follows:

Synura - cucumber odour. Spring and Autumn occurrence, though never abundant.

Asterionella - Present in large number during the winter months. This diaton produces a very decided odour. In small numbers it produces and odour resembling rose geranium; in large numbers it gives a decidedly fishy odour.

Mallomonas - This was never very plentiful. It produces a sweet smell like violets. In large numbers it produces a fishy odour.

Anabaena - was fairly plentiful during the month of June. This gives off a nasturtium odour, when present in small numbers. When present in large numbers it gives off the odour of a pigpen.

Tabellaria - when present in large numbers, as it was at the same time as the bloom of Asterionella gives off a decidedly fishy odour.

Eudorina - though never very plentiful in the lake at any time, this organism gives off a fishy odour.

Ceratium - has a vile stench and gives a rusty brown col-

oration to the water.

Dinobryon - was present in large numbers at various times of the year. This gives a fishy odour to the water.

Peridinium - gives off a strong fishy odour like clam-shells.

Considering the organisms present and the overlapping of their periods of abundance there is little chance for the water of the lake to free itself of these objectionable odours. The fact that the lake is a closed system, also prevents any chance of eliminating the odours present.

CONCLUSION

The need for the study of interrelationships in any ecological study is aptly described by Shelford (1931).

1. Weaver and Clements ('29) hold that food, rather than physical factors, controls animals, and, since plants are the direct and indirect food of all animals, the biotic community has unity through food relation.

2. The food relation, especially of abundant and influent animals, are usually flexible and rarely if ever obligate, and observation of apparently restricted food relations made in one locality may not hold good under other conditions.

3. The climaxes of nature (bioecological climax) include that vegetation which occurs with the pristine numbers and kinds of animals present.

4. Plants and animals tend to move together as a unit, and are governed by physical factors. Animals may, because of their motility find suitable place in advance of the appearance of the plants.

5. Animals are better short-period indicators than plants. Their presence and abundance at any hour, day, season or cycle is indicative of conditions relative to which plants cannot fluctuate at all or must lag behind indefinitely. One thus sees the pushing of the dry community animals into the wet community in dry seasons and vice versa, as a regular phenomenon (Gleason, '27) with attendant effect upon the habitat.

6. Law of Tolerance. The growth of an organism is pro-

portional to the nutrient substance present in minimal quantity, no matter how abundant others may be. Thus food, Temperature, light, moisture, etc; may be favourable while shelter is lacking, and animals, which otherwise would be present and abundant, are absent or found in minimal numbers only.

7. Food relation. Each species selects the food available in greatest quantity, making selection which in a particular locality tend to give an erroneous impression as to the specific nature of dood relations.

Of methods to be employed in the investigation of Animal ecology, he states: (1930)

1. Such studies should be carried through as many seasons as possible, but at least through two growing seasons, at the end of which biological differences may be correlated with weather.

2. -- in fact, all groups show fluctuations in abundance which are probably due to weather.

3. Papers on food relations should be accompanied by enough quantitative collecting of available food species to indicate the selection made by the specimen eating the d food. This brings out interactions of species.

These points tend to emphasize the intricacies of any ecological work and the necessity of approaching it from as many angles as there are ecological factors before any conclusion is made regarding their interrelationship.

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				5:30 RM		6:00 P.M.	6:15 P.M.		11:50 A.M.	4:45 P.M.		12:05 P.M.	5:10 P.M.	11:50 A.M.	[illegible]	[illegible]		11:23 A.M.	4:50 P.M.		12:00 N.	4:55 P.M.		11:45 A.M.	4:30 P.M.		11:50 A.M.	5:10 P.M.		11:45 A.M.	5:45 P.M.	
			216	76		108	104								2			Bottle	40			+					2			4	+	
				44		8	12		6	48								Broken	20		+			2	10		34	+		74	10	
			216	60		28	24		2	4		8	+		25.	8									+				2		
			8	4		12	16		45.	15.									4			+		6	10		2			+		
												8	+		5	4			2		15	4		2	45.					15.		
				8			4					45	4		5	6														12	28	
			4						4										12			8		12	4 young		2			2	
			24	20		376	96		44	34		200	96		26	212			684		64	204		226	180		14			16	22	
			4	40		24	8			4		+	+		4	12			376		4	12		4	22		10	2		4	4	
			4												2				68		12	8		6	+							
				1/2 haul												3															1 in haul	
																								2							
			4	72		16			22	32		32	24						4		4	8							2		
				64		16	12																	80	40		240	60		20	30	
			8				8																				2					
			120	88		36	60		20	20			100			10			4		90	100		10	10		20	40		20	30	
				4		4	2															2										
			720	620		540	480		180	260		1260	1440		360	500			3020		620	1000		710	410		220	120		60	80	
										40			40		8	60			108											2		
			4	4		4	4						4																			
																						4		2								
															2	4																
			20			8										2											2					
			100	240		48	32		70	60		80	100		40	40			140		20	40		80	50		30	50		10	110	
			160	148		12	24																							2	6	
									20	12					18	24			14					4	4							
									2							2																
						48																		20	40		20	2				
			32	8		36	8						8		8	16			20		140	80		1460	2		170	730		2	2	
			80	120		16	20									8			148		118400	18200			?		3510			80	90	
						4420	8140								+	3020			00		15-20 a sprig						20-30 a sprig			1180		
			320			48	8									sprigs												1102	258		Fe-w Sprigs.	
			84	72		8140	23480		21830	18480		29600	26640		4810	10360			19240		106560	84680		2890	1000		180	40		120	60	
																														4		
			20	100		12	4			4																		102	32				
			236	300		640	432		120	200		1200	1600		360	320			1060		1160	680		320	290		210	180		650	620	
				200		20	69		20	80		360	280		70	120			240		340	400		40	40		80	20		80	80	
				76		129	224		680	1300		6400	5440 + 55600 Pat.		990 + 9910 Pat.	1320 + 4070 Pat.			2260		2200	2260		1110	1530 Pat. + Frag.		480	270		200	250	
						12	16		2	+					4	4					20	20		2	2		2	2			2	
			780	720		896	282		350	400		6040	7040		100	200			160		4520	7120		720	300		410	550		2560	1000	
																														8-16 per colony.		
			32	24		100	80		100	120		2200	1600								960	1400		250	210		100	160		1000	610	
						12			160	200		13320	10340		2960	4440			100		80	400					230	140			60	
						44	36		882	900		680	?		+	+			20		7400	11100					20	100		170	170	
															2 strands				40		+	160		110	100		20	20				
															+	+			740					+								
															+	8-10 per c.c.																
																			240			280 +			20 10		20	80		10	90	

Station – 1 Surface hauls

Counts recorded as numbers per c.c. of 10 c.c. volume from 500' tow.

	5:00 P.M.	11:40 P.M.	1:30 P.M.	5:45 P.M.	1:45 P.M.	1:30 P.M.	5:50 P.M.	1:30 A.M.	12:00 Noon	4:50 P.M.	12:25 A.M.	11:35 A.M.	5:00 P.M.	12:40 A.M.	12:00 M.D.	4:35 P.M.	12:00 M.N.	11:55 A.M.	5:00 P.M.	11:30 P.M.	12:30 P.M.	3:03 P.M.	11:55 P.M.	11:53 A.M.	4:38 P.M.	12:45 P.M.	12:00 M.D.	5:18 P.M.	11:45 P.M.	11:30 A.M.	5:37 P.M.	12:25 A.M.
		3	800	160	275	50	38	108	2																							1
	6	42					2	8			5		5	+		+	5	+	5	+	+	8	8			2					+	2
	8	5	18	11	35	2						5	5		Bottle				2	+				2	10		1	1	3	10	9	9
	5	1		2		6	10	7	5	5	2				Broken				+		5				5	2			1			
												10	+	30		+	2	+		5		+	+	2	5		+		+			
						5					1	5	5	5		2	5	+			+	+	+	5	8				1			
	2	1	2																													
	3		2	2				2																						1	3
	2	10					2														+		8	2	18	3	2	1	2	1		1
	145	139	8	78	80	223	125	230	100	28	10	35	65	23		98	170	45	340	172	30	43	73	1395	1348	260		1	1	15	28	8
	25	35	2	10	8	8	2	10	5	5	3	+	10	2		2	20	+	103	28		13	10	18	90	23	2		3	1	+	+
				8												2		2	27	+	5	2	5	8	2				?			
			7 in haul	18 in haul	34 in haul	1 in haul	1 in haul.	10 in haul																								
	1	1																13 Small					2		+				1 in haul 1			3 in haul.
		1		1																												
				1																												
	5	8		5	10	5	2		15	20			25	13				2	10		+	2	2					+		1		
		2														5																
	300	150	13	75	50	25	25	13																					1			
																								75	25	63	13	81	85	19	6	6
		425	88	75	63	888	1250	250	25	13	6	25	75			25		13		13	100	2 50	75	100	13		25	113	6	6	13	6
						2	2							2																		
	800	900	138	238	420	150	88	175	250	113	44	213	600	175		290	125	675	2550	1288	500	775	38	1738	3356	975	56	63	19	19	19	13
		8	5	8	5	2	5	8	2		1	5 2	25	2		25 .2	38	25	450	200 2 2					2							
	2	5		2																				10	20				1			
			2		2																											
		733	25	25	50	300	50	88	88	113	44	38	150			38	38	38	163	88				188	88	106	38	31	38	6	6	13
			63	138	163	30	100	50																						25	25	6
									40	10	8					23	20	5	26	13					2							
						176	163		200		6														25		6			13	6	19
		300	6 25 Small Amount	28 63	25 75	10 38 4625	23 163 2300	35 38 5088			231 Small amount	10	5			7 25 2313	7 13 1888 10 per spring	5 13 3700	13 14 2313	5 13 2775	50 50 18500 19-26a spring	50 9250	63 9250	2 5100	4625	6938	106	850	125	2 185 19	100	1 69
	Peak	151	125	30 188	95 725	33 8094	18 16188	18500	22663	7313	13875	5550	16650	2775		8575	12025	12188	1480	7863	120250	64750	39775	31 5750	3700	694	464 50	40	108 31 1	†	17 69	50
		13																										2			13	1
		80	8	13	13	5	5	5	1		1													2			13	19	16		3	
	266	200	350	900	550	875	1050	680	200	238	31	700	275	275		650	125	1013	1375	400	725	225	950	788	975	219	131	118	75		269	238
	138	150	100	213	275	63	88	88	50	38	25	275	300	113		213	113	75	350	260	425	275	425	250	185	31	31		19	25	25	75
	250	438	200	713	563	750	450	889	1588	325	419	3500 + 80,000 Est. +	3225 + 198000 Est.	1420 + 7700 Est.		1230 + 9250 Est. 2	1400 + 6640 Est. 438	1213	1600	1650 2	1875 10	1500	1250 2	2350 5	2650 2	763	144	156 2	125	75	181	319
	1450	1950	225	263	625 2	913	913	500	538	288	106	2125	2425	550			350	375	438	350	3825	2200	3125	1238	1538	269	325	469	163 1	650	1000	688 1
	588	513	63	63	138	438	188	275	188	100	56	675	875	400			+				925	375	6500	485	725	183	119	150	19	256	269	288
						13	75	25	950	213	25	24975	3238	2775		2938	2438	2200	113	75	325	85	300	13	25		50	44	38		38	
						175	113	38	500	338	125	300	25	13		75					10175	4125	5550	25	50	13	25	81		50	88	56
																	+	+	13	13	25	+		100	88	25		25	13			
																25	13		463													
																		+	+	+				3								
																		150	388	423	375	175 13	225	88	25	6	18 6	50	13	13	31	C

Station – 2: Surface Hauls

Counts recorded as no. per c.c. of 10cc. volume from 500' tow.

12:30 P.M.		12:15 A.M.	1:45 P.M.	6:00 P.M.	2:00 A.M.	1:40 P.M.	5:30 P.M.	12:20 A.M.	12:15 P.M.	5:05 P.M.	12:35 A.M.	11:60 A.M.	4:50 P.M.	12:50 A.M.	12:15 P.M.	4:50 P.M.	11:50 P.M.	12:25 P.M.	5:12 P.M.	11:20 P.M.	12:45 P.M.	5:15 P.M.	11:45 P.M.	12:05 P.M.	4:45 P.M.	11:35 P.M.	12:10 P.M.	5:30 P.M.	11:07 P.M.	12:05 P.M.	5:29 P.M.	12:15 A.M.
		2	42	40	78	29	51	98	2																						
11		33		2	9	2	20	11		12	7	+		+		+	189	2	4	11	2	11	56 many young						+		+
9		28	7	22	24	2	2	4	13	2		+						2	2				4				+	+	1	2	11	4
2		2	45	4		9	2	2	2	2		+																	3		+	
												4	2	10	+		+	12	+	+	+	+	2	2	+			2	1		5	5
						4					5.	4	4	2	+	2	4	4	2	2		+	S.	S.		1						
2																																
4		2						2																						1	+	6
4		13					2	2	2		7		+					+		2		9	9 young present					3	2		2	
187		200	20	60	53	78	49	172	58	22	19	18	22	70	73	134	222	74	89	82	13	22	247	1001	84	82	4	1	1	6	22	19
31		49	7	38	2	7	13	11	2	25	7	4		+	9		18	9	11	38	+	7	22	7	2	4	2	1	1			
					4			2										2	2		1	7	16						1			
																	1 in haul +												2 in haul	2 in haul →		
			1 in haul Ghost Larva																					Ghost Larva				+			7	
4		13	11	12	9	7	16	31	24	16	20	12	12					2					9		1			1				
		2				2																										1
129		742	33	67	22	22	44	44	11															56	6	6	50	39	106	3	6	6
				2	2	2						2	2																			
44		322	22	178	56	500	1167	311	11		22	44	56			33	33	11			22	22	44	22	6	11	33	78	33	6		6
						2	2																									
1529		2433	444	578	588	200	89	256	220	167	200	333	433	222		222	822	1311	2222	1711	633	1411	2667	1855	577	494	28	106	72	11	28	11
									22			11		10	22	233	182	22	194	56												
				4		4	2	4	2	2														2	2	1			1			
4		4		4									2					2					1	6							1
															7			2	2												
			2		12		6																									
60		844	33	78	69	44	22	222	156	45		45	67		22	11	22	44	33	33	44		111	100	22	11		61	50	3	6	+
		2	67	99	149	56	67	44			2																					2
									27					4	9	9	20	38	24	18					2		1					
																				2					1							
						189	89	44						22											17	6				6	+		
167 Peak.		200	2	9	4	14	67	24					4	4		12	2	9	2	7				4				2				
			44	56	22	33	33	22			Low.				2222 Sprigs.	1140	11 270 80-30 per sprig	38	100	17	44	56	89	4933 Low.	1406	772		433	278	33	44	
720		922	58	111	89	27	35							6				4190	8340	7600	23900	15000 80-30 per sprig.	18700			44	95	206	189			
+		44	511	1712	469	35336	14389	24667	722	7400	10667	7400	6666	25664	3289	11056	28778	9644	4544	15622	68822	46674	98667	7400	1861	1028	50	39	28	39	11	61
		11																						7			1			6	3	6
11		103	12	7	12	11	7	11	4					4																1		1
41		178	211	622	500	1156	644	1289	722	300	100	478	244	178	300	344	156	578	444	900	444	378	844	700	228	1	50	55	41	339	172	239
133		356	89	189	67	100	78	111	+	67	22	167 1580+ 2700 Est.	311 760+ 111000 Est.	56 830+ 27000 Est.	133 860+ 5550 Est.	144 1174+ 7000 Est.	111 1070+ 3700 Est.	178 1100- Est. ~500 of these.	378 Nearly all stare	300 small Pecten	778 1/10 microcysts	778 1/6 micro	578	267	29	50	60	44	33	28	28	28
249		411	378	422	564	789	433	544	822	1422	633								2222	1783	1089	1133	1578	2633	917	406	152	233	167	100	89	100
						16	4	2	+			2			2			11			4	33	11	7	1		2	1				
1833		1856	1078	566	650	1524	554	578	344	478	344	1667	2900	888	311 mostly single	444	278	222	411 mostly single	289	3733	1833	4088	2600	383	139	361	517	222	778	778	733
578		711	278	133	200	778	232	156	133	156	67	722	667	444			–				933	511	400	689	194	61	117	206	56	278	256	1 273
			167				38	111	378	433	278	4111	2867	3289	2056	2056	1533	822	133	200	289	267	67	22	11		39	39	28	17	18	18
						123	144	100	378	522	544	88			+	111			1111		7448	2844	4111	44	22	11	72	67		78	44	44
												+	+	+				+	44	11	44	67	67	244		6	16	16	28			
															33	56			200	89		178	44			1	11		6			
																		133	500	367	289				6	6	33	56	39.	33	33	17
																											11					

Station – 3: *Surface haul*

Counts recorded as numbers per c.c. of 10 c.c. volume from 500' tow.

2:00 P.M.	6:15 P.M.	8:15 P.M.	5:20 P.M.	12:45 P.M.	11:25 A.M.	4:30 P.M.	12:40 P.M.	5:00 P.M.	12:45 P.M.	5:20 P.M.	1:00 P.M.	5:20 P.M.	12:15 P.M.	5:10 P.M.	12:30 P.M.	5:40 P.M.	12:20 P.M.	5:13 P.M.
23	100	30	110					7				7						
		3		3		10											+ Small	
	190	67	60	No	10		13	3+25	7	10	3	3	17	32		17	12	137
15.	85	7	5.	Haul.	+		45.	+	25		+		10	35.		1		
					65	65	125	3+75	45.	3+35.	45		3+75		1	+		15
	10																1	8
			3		1 in haul				+	+			7	1	+			+
27	83	117	110	43	57	13	97	210	37	200	50	33	527	65	3	5	8	43
7	17	13		3		3			+	17	3	10	17	3	1	3	+	1
								+	3	10	3	10	3				1	
		7																
	← 3 in haul	1 in haul																
	← 3 in haul						10	3			3							
3	20	7	10	20	10(?)			7	7		3	3	3					1
		5																3
	183	33					17						83	42	33	140	+	25
	30						7								(colonies present)			
10	183		250		33		17			33	17	17	17		42	17	5	33
		3																
443	983	67	100	200	500	550	367	80	367	3833	400	2000	2533	367	50	92	17	90
				17			17	3	3	67								
	1	3																1
												3						
							7											
		7																
																1		1
67	183	50	50	66	100	67	67	17	33	67			33	50	25	25	8	+
83	183	10	33			3												1
			1			7	43	30	70	40	3		17					
				10						3	3	1	3	3				1
		17	100										7	+		1		1
10	17	30	17		10	10	13	17		7				1	3			7
83	100	33	50				8		50	17	100	100	3100	708	192	250	50	630
		3700	1603				3083	2463 10 to spring	5550	7400 2 to a spring	27133	18500	+	+	+	4625	758	1350
	83		42												100	480		42
350	750	37800	31450	15413	6167	6167	8633	13567	16883	24667	160333	246667	37000	1233	25		50	200
															1			
																		7
7	18	2	7												7	62		13
2034	2233	1283	1783	190	417	500	467	533	267	1033	1200	667	800 150 micro.	183	267	225	383	1625
50	517	67		50	117	183	300	150	233	567	833	767	317	33	42	125	25	150
450	2500	967		833	2367 + 68,000 Ast.	1860 + 30,000 Ast.	3300 + 26,000 Ast.	1100 + 14,000 Ast.	2167	3500	2900	1900	3667	550	300	400	100	320
		23	10	+			10	17		3	13	17	3	7	17	7	7	
850	3433	118	833	783	2300	1367	817	1000	617	400	6000 mostly single	8066	2050	258	650	643	793	5150
3																		
183	500	583	767	250	1083	317					1333 small	1033 groups.	883	208	275 (2-4 in group)	167	443	1625
	250		?	417	6166	5550	4925	2456	250	283	533	167	17		86	50	17	17
	+	267	350	1133	133		67	67			12333	7600		17	50	75	50	142
										133	+	33	233	17	42			7
							133	133		3								
								+					+					
								133	133	227	400	800	33	50			25	50
											+	13		7				7

Station — 4: Surface Hauls

Counts recorded as no. per c.c. of 10 c.c. volume from 500' tow.

1:00 P.M.		Midnight	2:15 P.M.	6:30 P.M.	1:30 A.M.	1:40 P.M.	5:40 P.M.	1:10 A.M.	12:20 P.M.	5:00 P.M.	12:30 A.M.	11:50 A.M.	4:40 P.M.	12:30 A.M.	12:20 P.M.	4:45 P.M.	12:10 A.M.	12:05 P.M.	5:05 P.M.	11:45 P.M.	12:35 A.M.	5:05 P.M.	12:05 A.M.	12 Noon	4:45 P.M.	11:55 P.M.	12:05 P.M.	5:25 P.M.	11:22 P.M.	11:55 A.M.	5:30 P.M.	12:30 A.M.
+		4	52	100	98	26	134	334																								
2		34		10		2	6	28	1	48	4	+	4	+	+	+	8	+	2	6	+	38		+	+	4+2 young		+	+	4	3	1
8		24	2	20	22	2	8	16	2	4		+	+	4	R with Egg				6	4				2	2		3	+		2	8	1
2		6	4s		2s	8(?)	3s	2				+	2+6s	+		4							Bottle Broken	2	1+1s.	1						
2		4							1			8 Pas	+	8	2	+	+	+ 2s	2s					2		+						
						4	2			1s		8	2	8	+	6	+6s.	+4s	6s	2				2								
2			2					2																						1	
8		2		2				2																						5	3	2
4		22	2				8	2							+ Fertile Females	+	2	+	+	+		6		8	3	2 (young Few adult)	+ (young Few adult)	2	10	1	1	+
40		470	44	140	96	70	178	168	15	34	10	32	12	40	62	384	280	52	290	84	16	40		568	295	224	1	1	14	21	40	5
14			10	6	12	6	20	32	3	2	10	8		+	12	2	16	18	22	22	2	38		22	12	12	+	+	4	1	2	1
																		6	10	2	+	14		4	2						+
		4																													
1 in haul		1 in haul																													3 (in haul)
2							1	2										2 (small)													
2																															
		8	4	6	16	6	10	20	5	4	1	+		+		6		2	4			6							1	1	
						2																							1		
150		200	20	80	90	20	60	40							10									80	35	50	25	50	25	5	5	
				4		2		2				4																				
126		40	70	250	28	450	740	340	10	10	30	80	20	60	20	10	20	10	30	10	20	40		70	15	15	20		15		5	5
2						2																2									
1490		1500	200	930	860	180	100	220	110	130	160	600	360	120	120	470	430	1530	2600	1050	200	970		2690	830	725	60	80	60	5	115	5
										20		4				200	70	30	120	20												
2		4	2			4	4				2				2		2												1			
2		2																						14		6						
															2	2		2		2							1					
1			10	16	4		4						2																			
320		400	40	200	160	40	250	250	70	30	30	80	120	120	20	30	50	40	120	30				230	95	80	5	65	55	5	5	10
		2	170	140	220	50	280	60	5																					10	20	1
				2			60	44	20	20			8		14	16	20	26	20	20		2		2	2							
									1																	2(?)						
				80		170	120								2									10	10	1					5	5
2		2	6	4	4	14	42	18					4	12	6	6	6	6	12	4					2	2						
30		26	20	50	20	30	20	20								2	10	6	100	30	60	40		3700	3700	1850	165		300	50	185	
Peak				+		9240	5780	5180	+	+	+				1480	1480	1840	7400	5180	3700 90-400 sprig	6010 30 to 1 sprig			+			3700 10-15 sprig		1110 (6 per sprig)	185 (10 per sprig)	555 25-30 per sprig	185 10 per sprig
200		300	44	40	490	24	34			10	3																100	132	279		15	
110		120	280	560	420	31820	11470	7350	6845	9250	7400	13320	8140	3520	1850	11840	29600	16650	34000	9250	24400	730		7030	2035	1480	15	20	90	55	115	25
																										1						
																														9 sprigs		2
21		31	4	10	12	10	10	2	1	2	2																16		24		3	
200		250	490	740	530		760	670	90	180	40	860	320	400	210	330	160	450 30 micro	1260 100 micro	200 20 micro.	210 increase mins	280		680 (90 micro.)	140	120	70	180	65	255	280	130
100		40	40	150	90	90	40	60	15	40	+	300 3160 + 37000 Ast.	90 1290 + 30420 Ast.	180 3750 + 7900 Ast.	70 870+ 4440 Ast.	140 980+ 12210 Ast.	60 530 + 5180 Ast.		600	210	150	420		160	45	65	30		30	70	65	10
400		100	170	470	230	710	330	500	285	650	580							1200 + 740 Ast.	2960	1300	550	700		2010	390	485	160	.	120	185	250	50
			10(?)			14	14	2	3	+		4			2	2		4				4		4	2	2			1		5	
1240		1260	60	750	340	1410	730	260	255	310	180	3000	1200	2820 Mostly Gleocamp.	230	420	190	150	700	170	960 3 samp. 2 trawls with 2 6	1900		1000	235	300	205	565		760	1320	
																								2		1						
400		650	120	140	120	700	130	280	60	120	150	1300	370	1360	58			20				460		390	150	125	45	190	90	255	730	135
			+		120		20	50	390	120		3700	1480	4070	1480	1480	2220	5550	200	40	30	180			5	10	35	65	25	20	40	5
			+			110	160		470	450	370	160		120		30	20	30		10		2220		50	20	20	20	65	20	60	80	30
												+			+		+		40	20	50	20		140		5	30	5	10			
															30	60			120	40												
																	140		430	200	50								10	20	25	20
													+								+	+		20		5					

Station – 5: Surface Haul from Centre.
Counts recorded as numbers per c.c. of 10 c.c. Volume from 500' tow.

Organisms / Bottle	1.	11.	24	16	21	34	43	38	54	60	50	82	73	76	x5	x11	x2	x16	x22	x27	x33	x39	x30	x44	x50	x55	x58	x64	x69	x75	x83	x72
Month	July - 13		Aug. 28			Oct. 7			Nov. 11			Dec. 28			Feb. 23			Mar. 30			Apr. 27			May 31			June 26			July 20		
Weather	Cloudy Warm Fairly calm	Fairly clear No moon Calm	Humidity num Cloudy Slight ruffle	Shifty Hot Calm	Bright moon Mist rising from lake	Dull and cloudy Calm	Sun set Lake in shadow	No moon Mists rose rising off lake	Cloudy Slight breeze Ruffled	Cloudy Slight breeze Ruffled	Cloudy Haze on water Calm	Sunny Slight breeze Ripple	Cloudy Rough Ice on lake	Cloudy Hail storm No wind	Sunny Warm Ripple	Clear. Sun behind the hill Ruffle	Clear Frosty Calm	Sunny Cold Heavy wind	Sun behind hill Chilly. Ripple	Clear. No moon Frosty Calm.	Clear Sunny Ripple	Sun setting. Breeze Ripple	Clear. Stars Cool. Calm.	Sunny Strong breeze Rough.	Same	Clear. Stars Slight breeze	Sunny Warm Ripple	Sunny Warm Ripple	Stars Calm.	Clear. Not. Breeze Ruffle.	Clear. Not. Breeze.	Clear. moonlight Warm. Calm.
Time of Day			2:30-15'			3:50-18'			12:35-13'	11:45		11:45-15'			12:30-15'			12:35-15'			12:50-18'			12:19-18'			12:20-13'			12:15-18'		
Ceriodaphnia			2			4																										
Daphnia									6			3			2			8 Adults 8 young			12			2						1		
Bosmina									1			+			2			+									1			1		
Pleuroxus									1																							
Chydorus												+			+			4 s			2 s						+	+				
Alonella															1 s																	
Holopedium																																
Diaphanosoma																														1		
Diaptomus						1						+						+			+			1			1 young					
Nauplii			6			20			10			4			105			8			24			69						3		
Cyclops			6			3			11			1			20			26			22			6			1					
Canthocamptus																		4														
Ostracoda																																
Hyalella																																
Hydracarina												+			+																	
Chironomid Larvae																																
Asplanchna						5			7			10(?)									4											
Colurella																																
Conochilus			+																					20			15					
Diurella						1																										
Gastropus			20			50																		5								
Euchlanis																																
Keratella cochlearis			30			15			75			50			180			280			150			175			5					
" quadrata															50																	
Monostyla									1																							
Notholca longispina																								1								
" striata																																
Ploesoma			2																													
Polyarthra			20			35			20			15						10			10			35			5					
Rattulus cylindricus			20			20																										
Synchaeta						1			4						14						2											
Lepadella patella																																
?						10																										
Arcella						2																										
Ceratium						15																										
Dinobryon						+																										
Vorticella			10																													
Peridinium			90			35			3330			2220			29600			2960			22200			565			30			10		
Difflugia																																
Epistylis																																
Anabaena			1																								1.					
Aphanocapsa			120			130			135			60			100			140			200 Few Micro.			85			45			70		
Desmids			20			20			30			30			60			50			110			15			5			15		
Diatoms			250			220			640			3700			570 + 1850 - Ast.			350			430			200			65			220		
Euderina			+			1			+															1								
Glococapsa			200			155			215			215			200			14 one Glo.			860			60			60			235		
Glocotrichia																																
Sphaerocystis			20			30			70			50						+			160			75			15			100		
Richteriella						1			165			740			1480			+			90									30		
Selenastrum			+			1 (?)			235						+			+			1850											
Golenkina												20						+			+			10								
Spirogyra																																
Gomphosphaeria																					10											
Lyngbya																											5					
Mallomonas																		60			80											
Pediastrum																																

Station - 6: Vertical Haul, showing seasonal variation.
Counts recorded as numbers per c.c. of 10 c.c. Volume obtained in length of hauls noted.